Liquid Argon Time Projection Chamber as a Neutrino Detector

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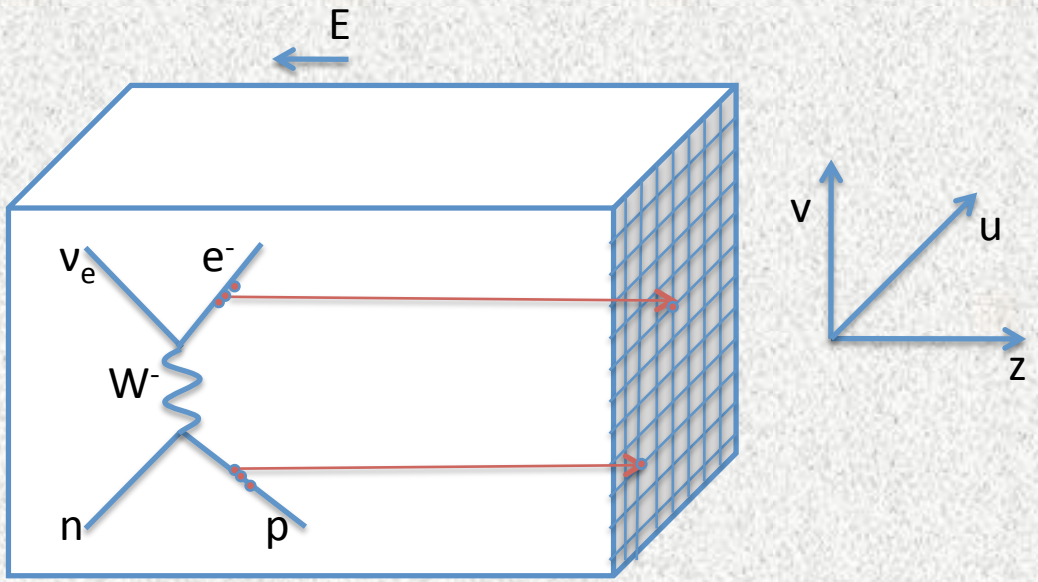
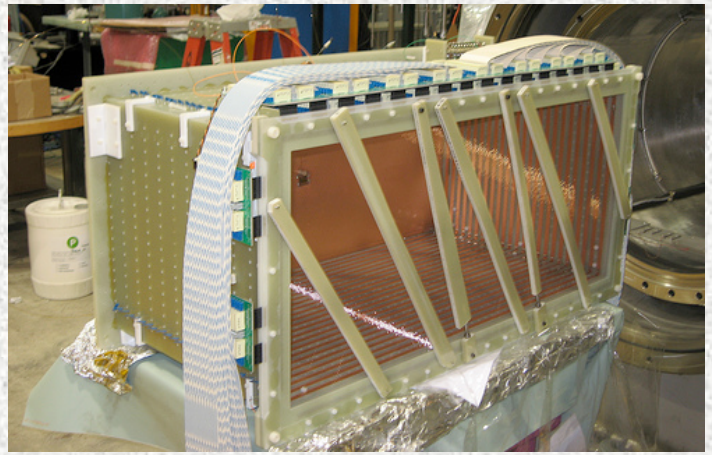
FNAL Summer Intern Presentation
July 30, 2008

Liquid Argon Time Projection Chamber (LAr TPC)

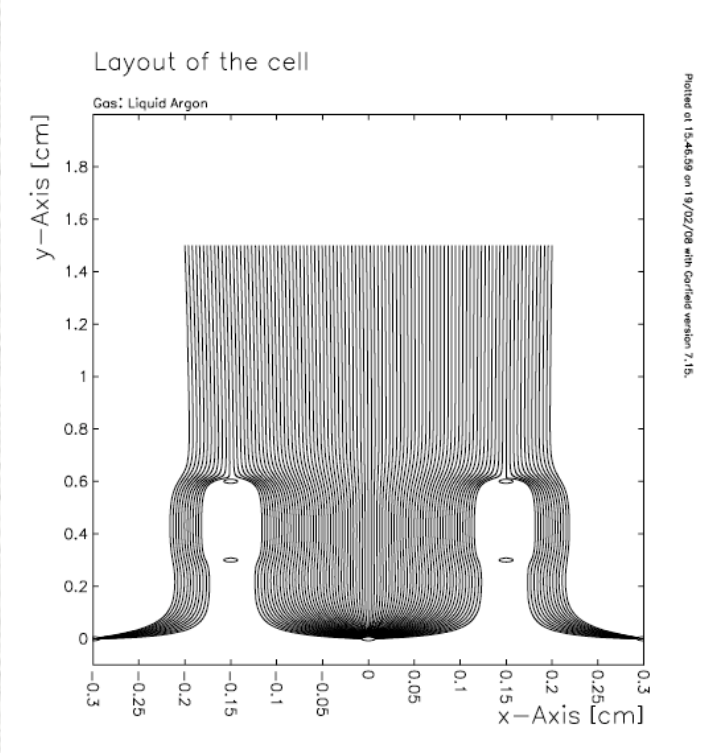
- TPC Invented by David Nygren (LBNL)
- Events ionize LAr
- Constant E field causes electrons to drift to collection planes
- Offers high spatial resolution and energy measurement
- Can differentiate between single electrons and photon conversions
- Less noise from misidentified events
- Displays events in entire volume
- Allows for smaller detectors (4X)





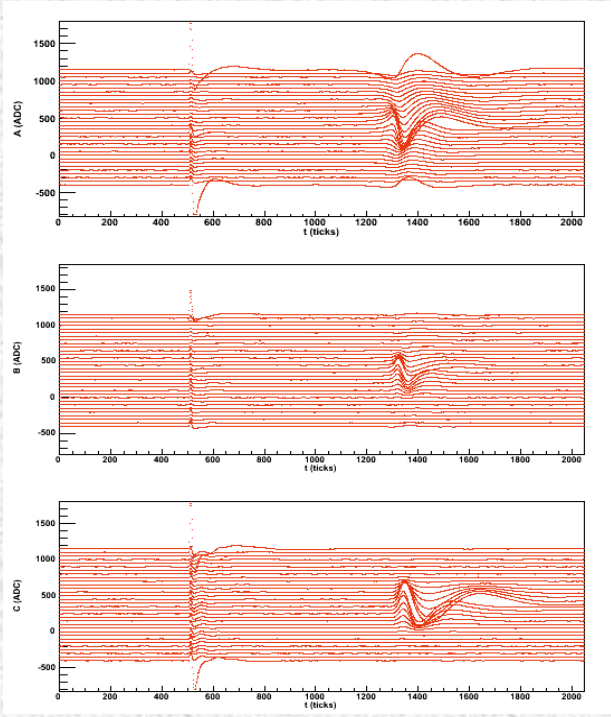
T962 TPC

LAr TPC Signal



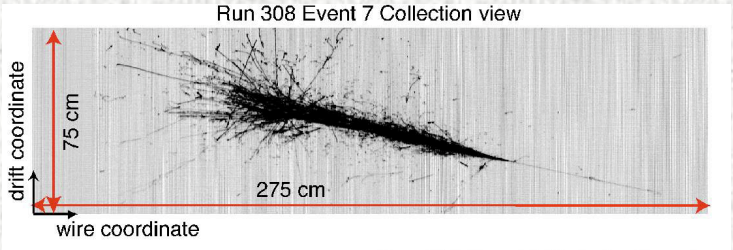
Electron Drift Lines

Made by Bruce Baller using Garfield-9



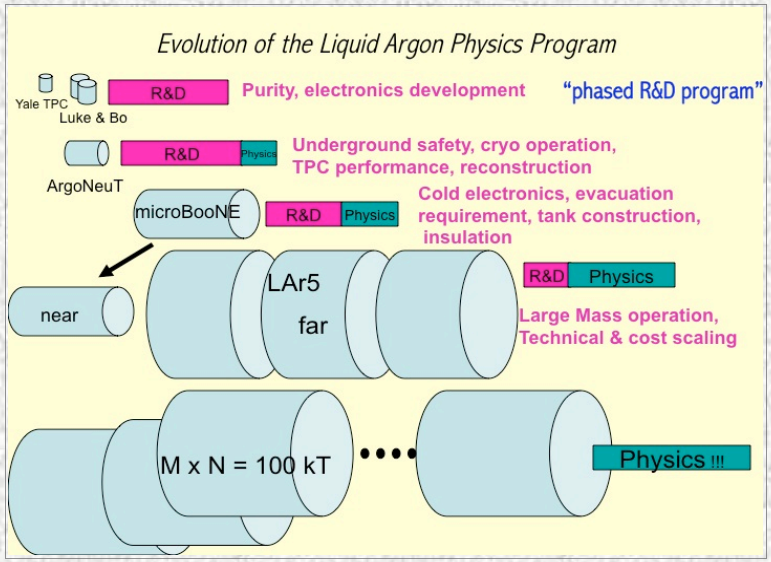
Bo event displays

Brian Rebel



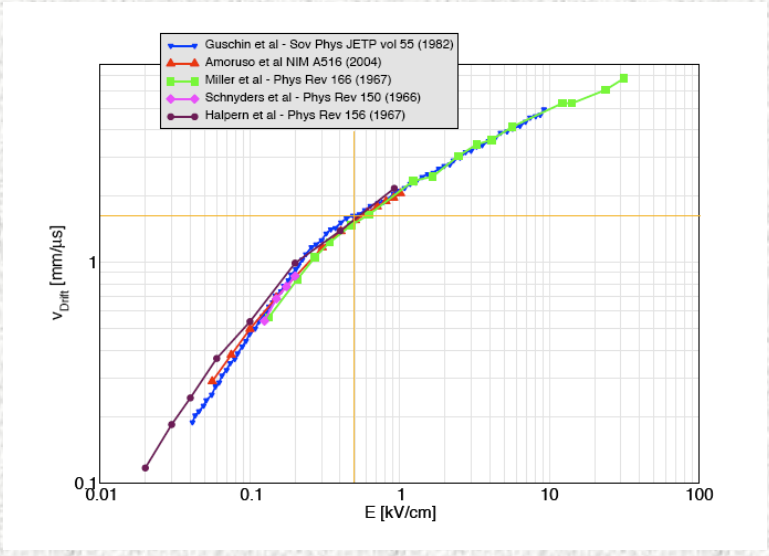
ICARUS event

Some TPC Parameters



- Size
- ArgoNeuT ~ 1/4ton

- v_D
- Determined by E
- Too high -> unwanted ionization
- Too low -> higher capture risk

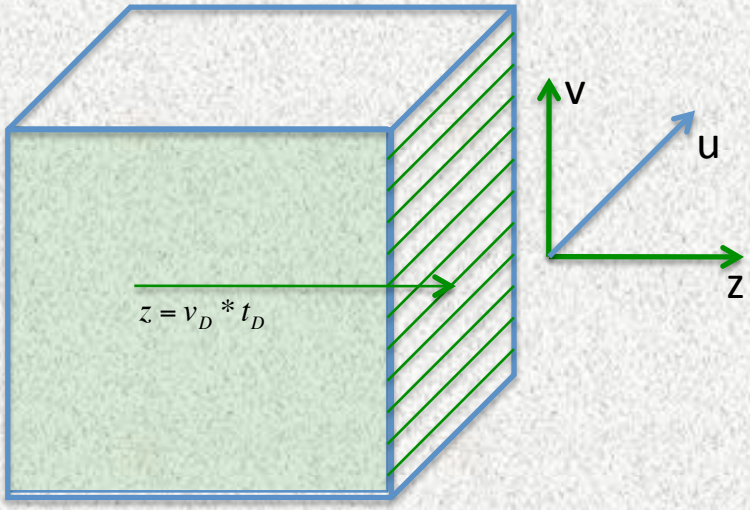


- Wire spacing (pitch)
- Small pitch -> higher, but more costly, resolution
- Use Monte Carlo (MC) to optimize wire spacing and cost

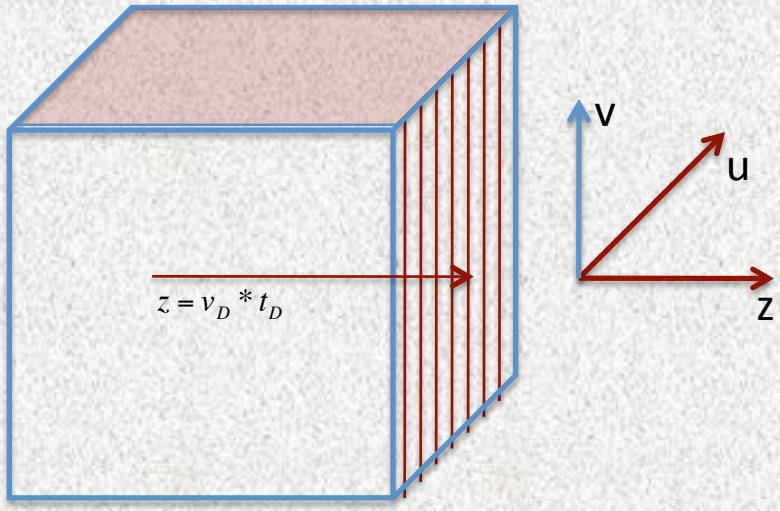
TANAL

- A MC program written by Bruce Baller to simulate long baseline events
- Studying ν_μ -> ν_e oscillations from NuMI beam
- For a 250cm X 250cm X 250cm TPC
- v_D = 0.16 cm/μs
- E = 500 V/cm
- L ~ 800m (Ash River)

Two Views

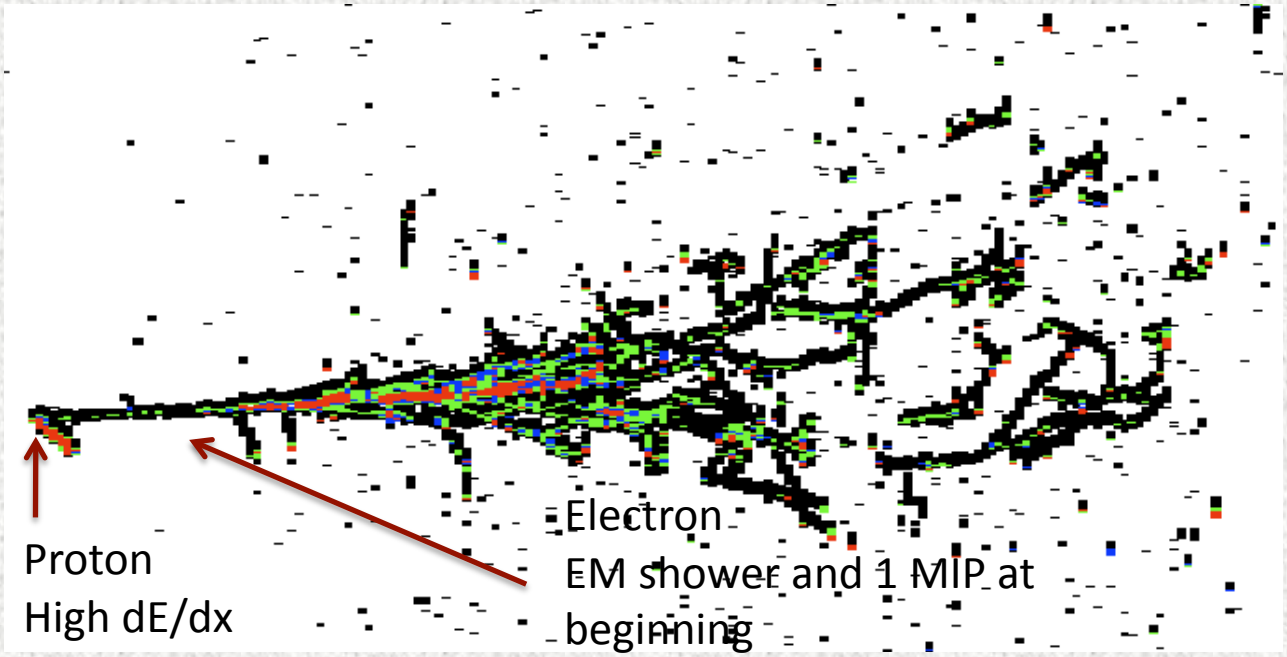


Collection Plane View



Induction Plane View

Sample event



Charged Current Quasi-elastic scattering (CCe QE)

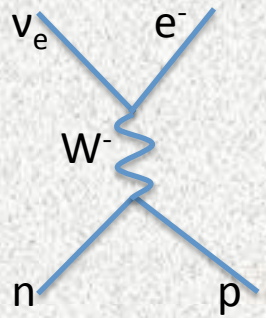
Wire Spacing Optimization

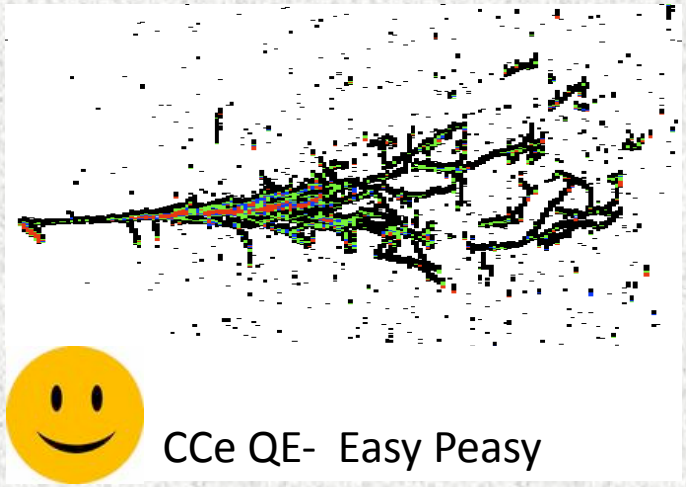
- ~1500 neutrino events are generated
- A maximum energy cut is made (E > 3.5GeV)

  ν_μ -> ν_e max at a few GeV and high energy CCe events easy to ID
- Also require an electron event to occur either 2cm or 5cm from the primary vertex
- Want to ID charged CCe from CCMu and NC events to determine best pitch and also approximate the background noise of future detectors

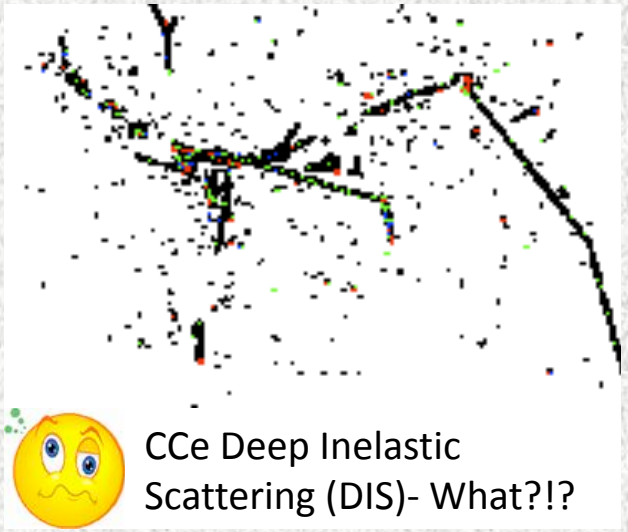
CCe

$\nu_e + n \rightarrow e^- + p$

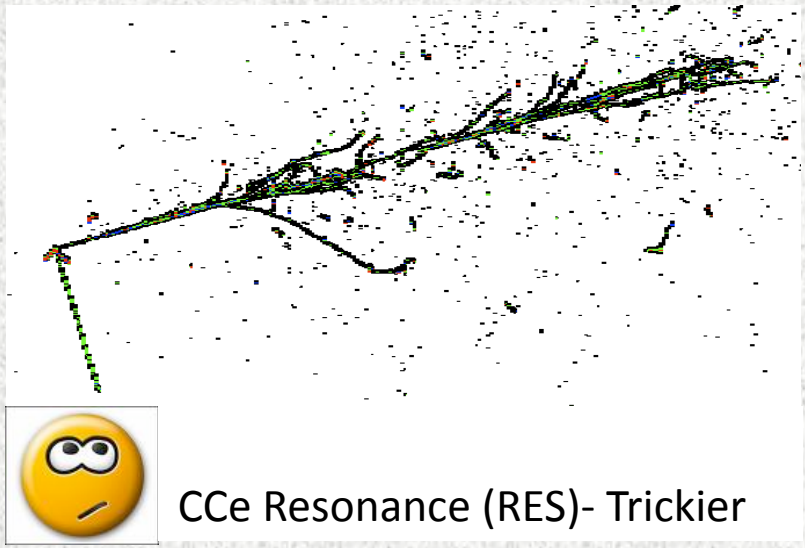




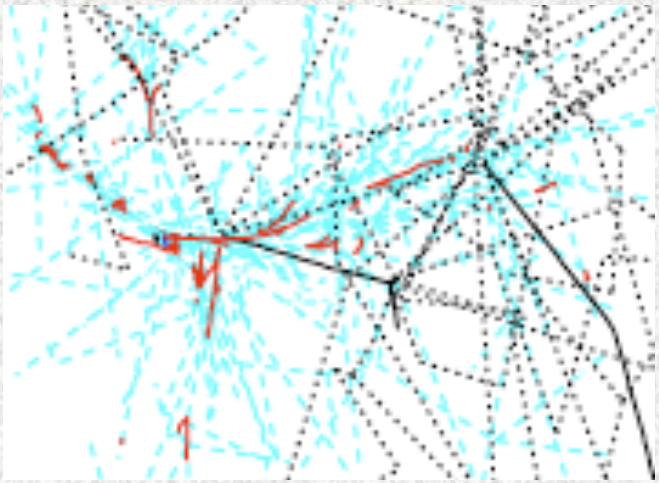
CCe QE- Easy Peasy



CCe Deep Inelastic Scattering (DIS)- What?!?

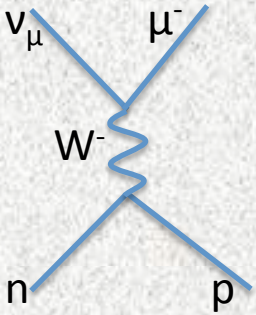


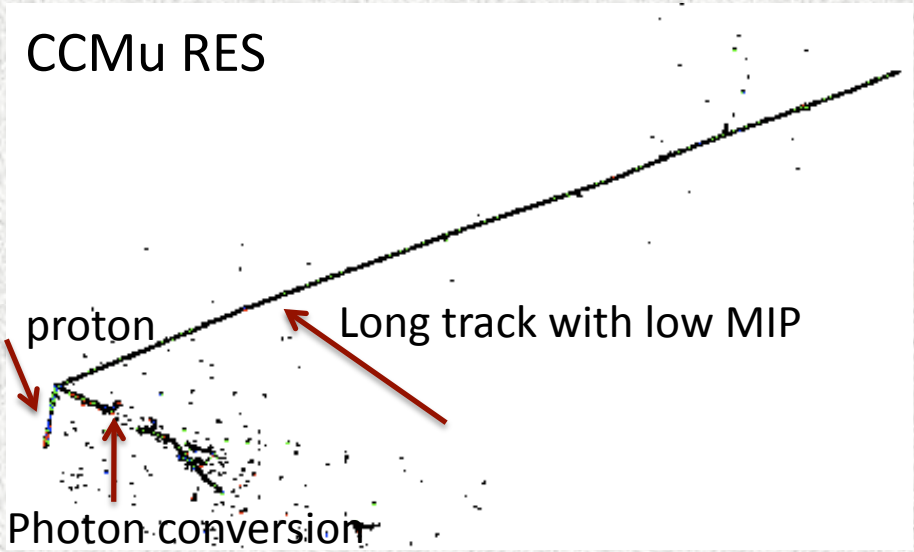
CCe Resonance (RES)- Trickier

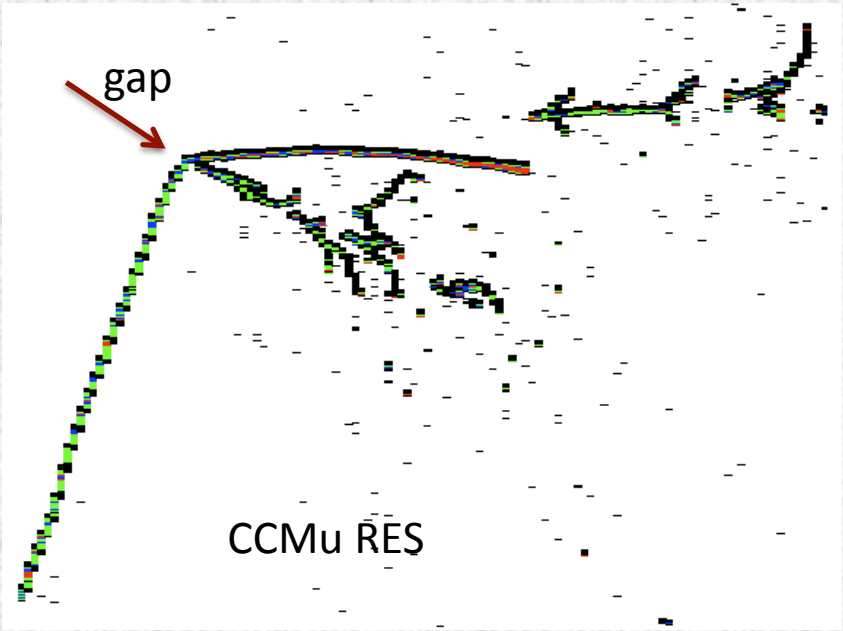


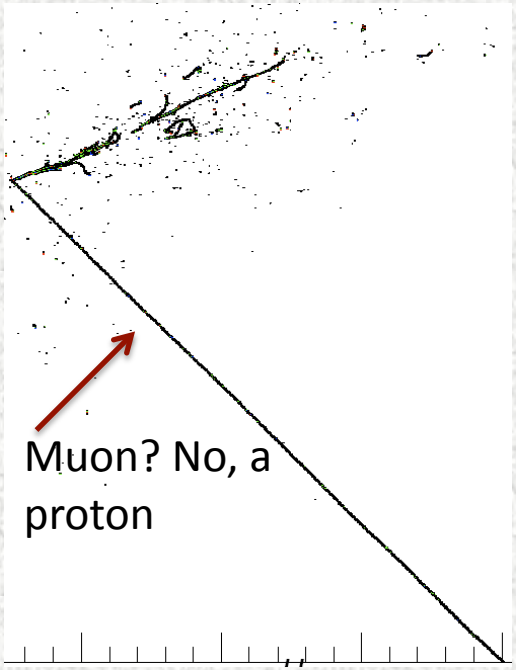
CCmu

$\nu_\mu + n \rightarrow \mu^- + p$



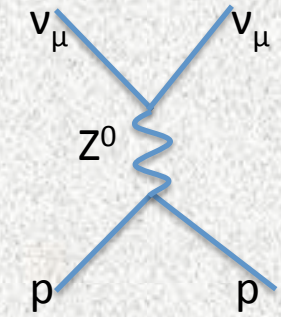


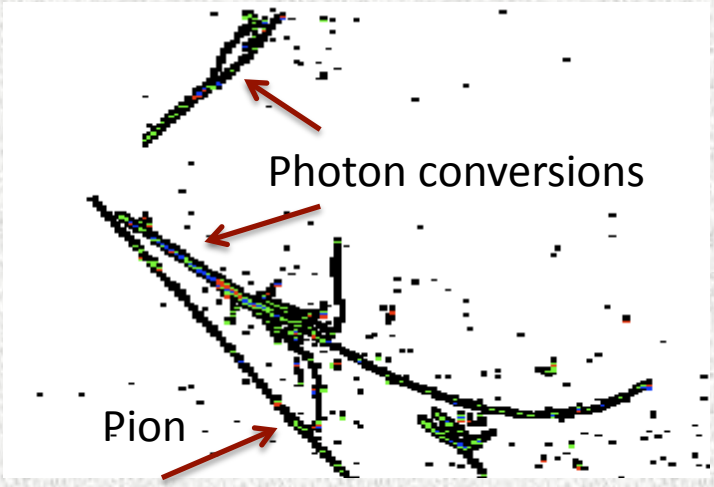


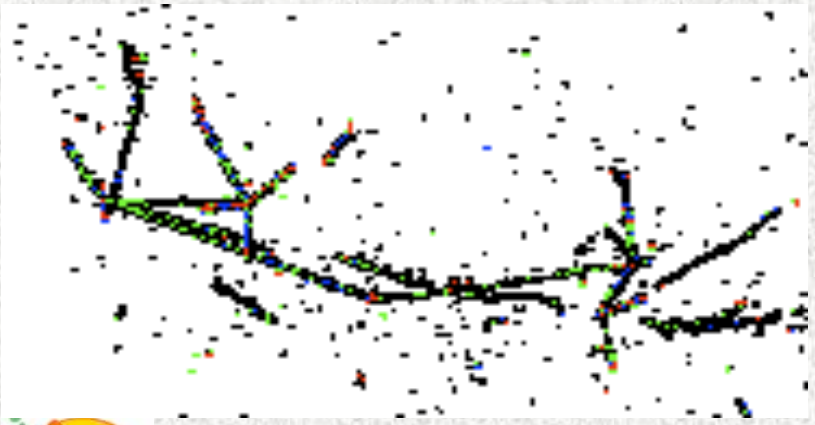


NC

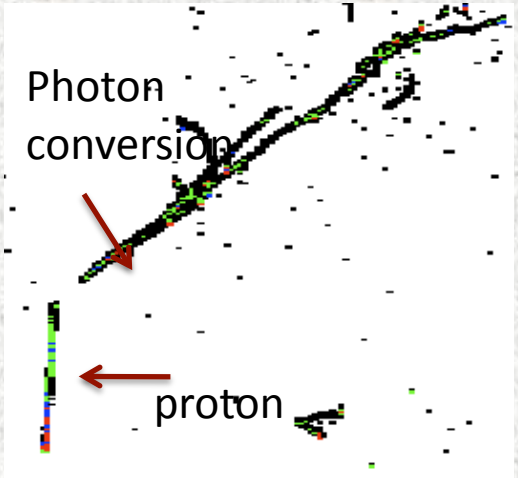
$\nu_\mu + p \rightarrow \nu_\mu + p$

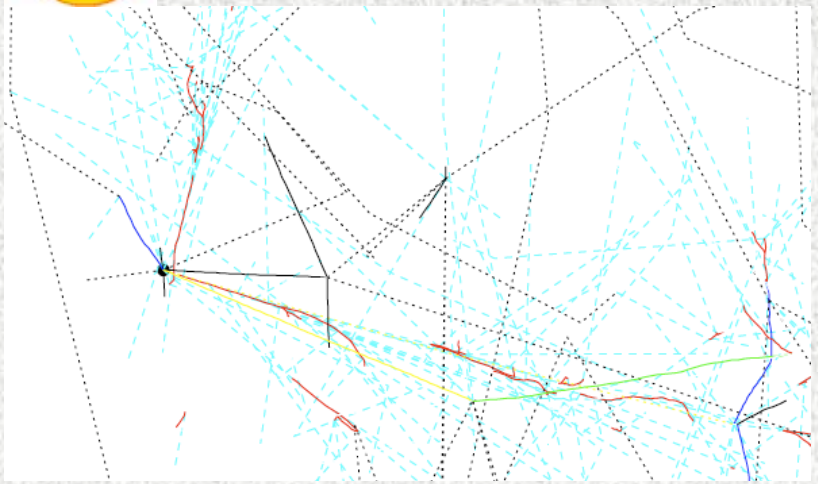






NC DIS





My Scanning results

e^- 2cm from vertex

	5mm	10mm
CCe ID	95.50%	98.70%
NC rejection	99.54%	99.26%
CCmu rejection	99.74%	100%

e^- 5cm from vertex

	5mm	10mm
CCe ID	90.10%	80.20%
NC rejection	99.18%	99.04%
CCmu rejection	100%	99.51%

Conclusions

- No significant difference between 5 and 10mm spacing for first set
- 10% better with 5mm spacing for the second set

What Next?

- More scanners to determine wire spacing
- Write analysis (decision tree, neural nets) to classify events
- Test analysis with MC
- Use analysis on real data from a future detector

A big thanks to…

- Stephen Pordes
- Hans Jöstlein
- Jamie Molaro, Patrick Swanson, Leonel Villanueva
- Bruce Baller
- Everyone at PAB
- Marj Corcoran
- Rice University Physics and Astronomy Department

Bibliography

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- R. Rameika. “LAr5- A Liquid Argon Neutrino Detector for Long Baseline Neutrino Physics” March 27, 2008 PAC Presentation
- ArgoNeuT: Mini LArTPC Exposure to Fermilab’s NuMI Beam <http://t962.fnal.gov/index.html>